One Health 10 (2020) 100154

Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

Profiling the public health risk of canine rabies transmission in Kogi state, Nigeria

S.S. Okeme[a], G.S. Kia[a], Philip P. Mshelbwala[b,c,*], J.U. Umoh[a], R.J. Soares Magalhães[c,d]

[a] Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, Zaria, Nigeria
[b] Department of Veterinary Medicine, University of Abuja, Nigeria
[c] UQ Spatial Epidemiology Laboratory, School of Veterinary Science, The University of Queensland, Gatton, Australia,
[d] Children's Health and Environment Program, UQ Children's Health Research Centre, The University of Queensland, Brisbane, Australia

ARTICLE INFO

Keywords:
Rabies
Transmission
Vaccination

ABSTRACT

Recently reports have emerged of rabies outbreaks in townships close to the city of Lokoja, the capital city of Kogi State in Nigeria. Areas in Lokoja are known to have high rates of dog bites and dogs are frequently butchered for human consumption, both of which may constitute risk factors for rabies transmission. However, data on the relative importance of these factors on canine rabies exposure in the densely populated capital of Kogi State is scarce.

To understand the risk for public health two separate observational cross-sectional studies were conducted in Lokoja. Firstly, a retrospective study was performed to investigate the human profile of dog bite injuries and quantify the vaccination coverage of offending dogs. Information on dog bite cases and vaccination records covering of 11 years (2003 − 2013) were obtained from the largest public veterinary clinic (i.e. State Veterinary Clinic) and a private veterinary clinic in Lokoja. Then, an investigation of the presence of rabies antigen in the brain tissues of dogs slaughtered for human consumption in Lokoja was performed. A total of 208 canine brain samples from five slaughter points within the army barracks (the main venue in Lokoja where dogs are slaughtered for human consumption) were examined by fluorescent antibody technique.

Out of 95 human dog bite cases, 46 (48.4%) were in persons between 10 and 19 years of age and 57 (60%) were males. There was a statistically significant association between gender of victims and their age, with a greater proportion of bites in males < 10 years of age compared to other age groups ($P < .001$). Our results indicated a higher frequency of dog bites on the legs (51%) than other parts of the body; vaccination rates of offending dogs were lower compared to the general population of dogs presenting to clinics in Lokoja (25% vs 31%, respectively). Rabies antigen was detected in 11/203 (5.3%) brain samples from dogs slaughtered for human consumption.

Paediatric dog bites and dog slaughtering practices represent a significant public health risk to residents of Lokoja in the context of rabies exposure. In order to minimize the risk of rabies outbreaks in children and people butchering, handling and consuming dog meat, dog vaccination and health promotion and education should be prioritized to these high risk groups.

1. Introduction

While rabies is a vaccine-preventable disease, it still poses a significant public health problem in many countries in Asia and Africa where 99% of human rabies deaths occur [14]. In these highly endemic countries, bites from infected dogs continue to be the main mode of transmission to humans [31]. Health promotion for the prevention of dog bites, dog vaccination and post exposure prophylaxis of humans are considered the cornerstones of effective rabies control programs worldwide. Controlling rabies in dog populations by means of vaccination is the most cost-effective, long term approach to preventing human rabies than reliance on post-exposure treatment of dog bite victims [16,32]; however, this can be a challenge in many regions.

Risk factors driving human rabies exposure remain poorly understood, in many communities in Africa, thereby hampering targeted deployment of resources to communities most in need. Nigeria has long been considered a high-risk country for rabies exposure [7,13], although the problem is poorly quantified because of inadequate surveillance. Information about rabies is available from case reports involving local residents ([2,5]; Philip Paul [23]) or travelers [13] but national surveillance data are lacking. Lokoja is a highly populated region that is of concern because of its proximity to known high risk areas of Nigeria and a rapidly growing

* Corresponding author at: Department of Veterinary Medicine, University of Abuja, Nigeria
E-mail addresses: philbwala@yahoo.com, p.mshelbwala@uq.edu.au (P.P. Mshelbwala).

https://doi.org/10.1016/j.onehlt.2020.100154
Received 18 November 2019; Received in revised form 9 July 2020; Accepted 9 July 2020
Available online 21 July 2020

population from an influx of people from different parts of the state. While dog bites in Lokoja are anecdotally common, reliable data on the public health risk of dogs in Lokoja are scarce, hampering a thorough assessment of the full impact of rabies in both human and animal health.

Several studies have indicated that rabies virus can be carried and excreted by apparently healthy dogs in Nigeria (Oboegbulem 1994, Ajayi et al., 2006, [22,27]). Anecdotal evidence indicates that rabies transmission can happen through direct contact with contaminated bodily fluids as a result of livestock slaughter practices [29]. For example two patients without previous history of dog bite were reported to have died of rabies. Further investigation indicated that rabies transmission likely occurred through fluid contamination occurred while there were processing dog and cat meat [29]. Dog meat has been proposed to have a variety of uses, including a cure for malaria, spiritual protection and enhancement of male libido. These sociocultural aspects further complicate rabies control efforts in most developing countries, concerns that are heightened by prior studies that have demonstrated rabies antigen in brain samples of dogs slaughtered for human consumption and risk practices among butchers ([4,12]; P. P. [22]).

The aim of this study was to provide a comprehensive One Health evaluation of the public health risk of rabies transmission in the city of Lokoja, Nigeria by profiling dog bites in humans and offending dogs and investigating the presence of rabies antigen in the brain of dogs slaughtered for human consumption in the city.

2. Materials and methods

2.1. General characteristics of the study area

The study was conducted in the city of Lokoja, the capital city of Koji State in Nigeria. Lokoja city is located at a latitude of 7˚30′N and longitude 6˚42′E, has a land mass of 3180 km^2 and a population of 195,261 people (2006 Nigerian population census). The city of Lokoja serves as a gateway to the nation's capital from the eastern and the southern states of the Federation. Within the city of Lokoja there is a Federal Medical Centre, a General Hospital, two State Veterinary Clinics and a private veterinary clinic. In this study setting, human dog bites are typically recorded in veterinary clinics. This informed our decision to use the clinical records of veterinary clinics as our primary data source for our investigation. In addition, dogs are slaughtered for human consumption at various slaughtering points within the army barracks in Lokoja.

2.2. Study design

Our study was divided into two separate investigations. The first was to evaluate the epidemiology of dog bites and vaccination rates of dogs presented to veterinary clinics and veterinary treatment, and for those implicated in human dog bites. For that we conducted a retrospective study of clinical records at the two major veterinary clinics in Lokoja (i.e. Kogi State Veterinary Clinic and the largest private veterinary clinic in Lokoja) from January 2003 to December 2013. Vaccination certificate records (Pet Green Book) were used to confirm the vaccination status in this study. Secondly, to assess the public health risk of dogs for human consumption at the army barrack slaughter points in Lokoja, the prevalence of rabies virus in brain tissue from slaughtered dogs was investigated.

3. Data on cases of human dog bites and offending dogs

Clinical record data of human dog bite cases and dogs brought to the two major veterinary clinics in Lokoja between 2003 and 2013 were assessed and retrieved. First, for human dog bite cases we retrieved data on age, gender, body site of bite and month of occurrence; as for offending dogs we retrieved information on sex, breed and vaccination status. Second, we recorded data on age, sex and vaccination status for all dogs brought to the clinics for routine veterinary checks and treatment.

4. Dog brain tissue sampling, collection and processing

Purposive sampling was read- used to collect dog samples in five slaughter points in the same area listed above to estimate the prevalence of rabies carriage in brain samples. Sample size for dog brain sampling was determined by using the formula by Thrusfield (2007).

$$N = \frac{Z^2P\ (1\text{-}P).}{d^2}$$

Where N = total sample size, Z = 1.96 standard normal value for desired confidence (normal distribution table), P = design prevalence rate (15.8%) based on [33], (Benue State), since there is no record of any prevalence rate for Kogi state and d = desired absolute precision which was set to 0.05. This yielded a total sample size of 204 which was increased to 208 to minimize sampling error and increase precision.

5. Protocol for brain tissue sample collection and laboratory analysis

Brain tissue samples from slaughtered dogs were collected between July 2014 and September 2015 from five slaughter points. Dog slaughter points are denominated 'Joints' (synonymous to pubs) where dogs are held caged, slaughtered and processed for consumption within the study area. The dog heads were bought and information on the source and sex of the dogs presented for slaughtering was obtained from butchers. Each slaughter point was visited twice daily (morning and afternoon) and dog heads were collected based on availability. Samples were stored on ice and transported to the Viral Zoonoses Laboratory of the Department of Veterinary Public Health and Preventive Medicine, Ahmadu Bello University, Zaria, Nigeria for fluorescent antibody test (FAT) as described by [10]. The FAT, is recommended by the WHO, with a sensitivity and specificity, between 95 and 99%, when fresh samples are used within few hours (P. [20,30]). The whole brain was extracted and sample of the brain stem was smeared using sterile swab sticks on one part of a slide and then was air dried and fixed in cold acetone for one hour at -20 ˚C. The slides were air dried and then the rabies conjugate was applied at 1:40 and incubated for 30 min at 37 ˚C in a humid chamber. Excess conjugate was removed from the slides by rinsing it with 7.4 pH PBS solution for 3–5 min and slides were allowed to air dry. The cover slips were mounted with buffered Glycerol Mounting medium and the slides were examined using a fluorescence microscope within 2 h of staining. When brilliant apple-green fluorescence color or greenish yellow objects are exhibited against a black background the test slide was deemed positive.

6. Data analysis

Data on human dog bites were presented as tables and graphs to show the distribution of bites by age, gender and site of bite of victims. A Chi-square test was used to test statistical differences in the proportions of categorical variables such a gender, vaccination status, breed and site of bite, and age and gender of victims. Age of the victims of dog bite was classified into two categories (i.e. 0–10 and 10 > years). A value of $p < .05$ was considered significant. All analyses were conducted using the Statistical Packages for Social Sciences (SPSS) Version 17.0.

7. Results

7.1. Profile of human dog bite injuries and demographic characteristics of offending dogs

Ninety five dog bites were identified. Young children were over-represented, with 81% (77/95) of bites were to children under 10 years of age. Males accounted for 57 (60%) of bites ($p > .055$). The anatomical location of the bite indicated higher frequency on the legs 51 (50.5%) than other parts of the body gluteal area, 30 (30.5%), hands 7 (14.7%) head 2 (2%) and back 5 (2.1%). Our results show a statistically significant association between sex of victims and their age, with a greater proportion of

bites in males < 10 years of age compared to other age groups ($P < .001$). Monthly distribution of dog bites indicated that the highest frequency of dog bite cases occurred between the months of October and February peaking in December and January with 25 cases in total (27%) (Fig. 1); the fewest number of bites were reported in April (4, 4%).

Information on the breed of offending dogs indicated 74 (79%) were local breeds, 18 (19%) mixed and 3 (3%) pure breeds. The majority 58 (61%) were male. Only 25% of dogs implicated in bites were up-to-date with their vaccination at the time of bite.

8. Rabies vaccination coverage in dogs presenting to clinics in Lokoja

Review of the annual rabies vaccination profile of 4281 dogs presented to the clinics in Lokoja during the period under review showed that 1339 (31%) of dogs received anti-rabies vaccination (Table 1). Vaccination was significantly more common in male (768, 57.4%) than female (571, 42.6%) dogs ($p = .002$). (Table 2). Most vaccinated dogs were 3–12 months of age ($n = 683$, 51%) followed by dogs in the ages range > 12–36 months [$n = 426$ (32%)] and dogs > 36 months of age [$n = 230$ (17%)] (Table 1). Local breed of dogs had the highest vaccination rate ($n = 585$, 44%) compared to 417 (31%) and 337 (25%) in exotic and mixed breeds, respectively ($P = .01$).

9. Detection of rabies antigen in dogs for human consumption

Between February and June 2016 a total of 208 brain tissue samples were collected from various slaughter points within the study area. Most brain samples were collected from dogs originating from the Plateau region [$n = 96$ (46.1%)], followed by dogs from Nasarawa region [$n = 83$ (39.9%)] and dogs from Kogi region [$n = 29$ (13.9%)]. Out of the 208 dog brains tested for rabies antigen, 151 (75.2%) were males. Eleven samples (5.3%) were positive for rabies antigen (Table 2). Most positive samples came from Plateau ($n = 6$; 2.88%) while the remaining were from Nassarawa ($n = 3$; 1.44%) and Kogi ($n = 2$; 0.96%) (Table 2).

10. Discussion

In this study, we found that the majority of dog bites occur in males (60%) and individuals between 1 and 10 years, which may be partly attributed to previously documented risk taking behaviors of male children towards dogs. Indeed, this finding is in agreement with other reports where children were found to be the major victims and more vulnerable to dog bites partly because of lack of awareness of the dangers of rabies as well as dogs viewing them as easier targets due to their small size ([17]; O J Awoyomi, 2007). Other authors had also reported higher bite frequencies among boys compared with girls which can partly be explained by gender differences in behavior around dogs [1,15].

We found a high frequency of dog bites on the legs (51%) and majority of the bite cases were associated with local breed of dogs (79%) which are predominantly found in the study area and generally roam freely through communities. While the results obtained in this study showed that local dogs are more likely to be vaccinated when compared to exotic breeds the low vaccination rate among dogs implicated (25%) is of grave public health concern. Furthermore, lower body bites are associated with an extended rabies incubation period, thereby leading to a longer time for rabies to manifest and a false sense of security.

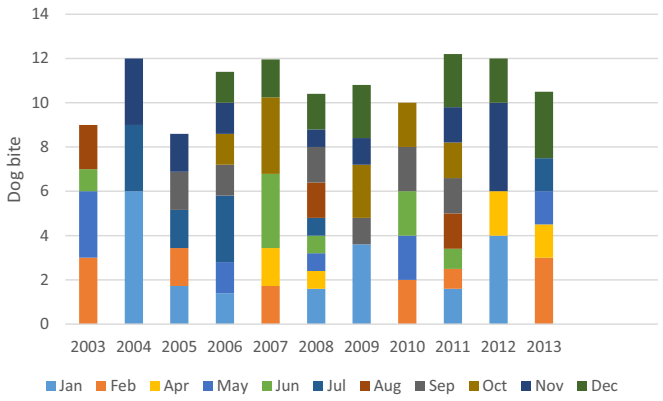

Fig. 1. Monthly dog bite cases in humans reported to the state veterinary clinic Lokoja from 2003–2013.

Table 1
Distribution of sex of dogs vaccinated against rabies by sex, age and breed in Lokoja from 2003–2013.

Year	Number of Cases	Number of ARV	Percentage%
2003	355	116	32.7
2004	406	123	30.2
2005	395	128	32.4
2006	402	130	32.3
2007	325	121	37.2
2008	359	128	35.7
2009	417	113	27.0
2010	407	119	29.2
2011	329	92	28.0
2012	426	134	31.5
2013	460	135	29.3
	4281	1339	31.2
Sex			
Male	772(57.7)		
Female	571(42.3)		
Age			
3–12	683(51)		
> 3–36	422(32)		
> 36	230(17)		
Breed			
Local	585(44%)		
Exotic	417(31%)		
Cross	337(25%)		

Our results also indicate significant seasonal variation in dog bites as an important epidemiological feature of reported cases. The higher frequency of dog bites during the dry season (from October to March) – with one-quarter of attacks happening in the months of December and January – corresponds to a heightened risk during the breeding season of dogs in this area [26]. During this period, the increased conflict between male dogs in search for partners can in one hand lead to increased rabies transmission between dogs but also more aggressive behaviors towards humans.

Overall our results indicate that vaccination rates of dogs presented to veterinary clinics for routine check-up (and those implicated in dog bites) is very low compared to the WHO minimum requirement (31% vs 70%) (World Health Organization (WHO): WHO Expert Consultation on Rabies: firs report. WHO Technical Report Serial 931 Geneva, 2005). The vaccination profile of dogs presented to clinics showed that local dogs had slightly higher vaccination coverage (14%) than exotic (10%) and cross breeds (8%) which is in contrast to previous studies from Nigeria [eg. in Ibadan (O J Awoyomi, 2007) and Gwaggwalada, (P. P. [21])]. Furthermore, our findings indicate that dogs of 3–12 months of age had the highest vaccination coverage (51.3%) which can be the result of veterinary advice to dog owners on the need to vaccinate their dogs from 3 months old and above; this is however well below the required 70% coverage. Theoretical

Table 2
Distribution of dog brain tissue samples by source of dogs slaughtered in Lokoja.

Characteristics of slaughtered dogs	No. examined (%)	No. positive (%)
Sex		
Male	151 (72.5)	8 (5.3)
Female	57 (37.9)	3 (5.3)
Source of dogs		
Kogi	29 (13.9)	2 (0.96)
Nassarawa	83 (39.9)	3 (1.44)
Plateau	96 (46.1)	6 (2.88)
Total	208(100)	11(5.28)

and empirical studies have shown that inclusion of puppies in rabies vaccination campaigns is likely to result in substantial epidemiological and economic benefits ([8] [9]. Dogs less than 6 months are significantly important in rabies transmission to humans [18,19] and more likely to be accessible for parenteral vaccination than older dogs. Additionally, children are fond of puppies, thereby more predisposed to contracting rabies, should they be rabid. The sex of dogs presented to the hospital for routine check may affect the vaccination coverage in the study area, as more males (57.6%) were vaccinated than females (42.4) may be as a result of desire of many dog owners preference for male dogs for personal security.

Our findings demonstrate that the presence of rabies antigen in brain tissues of dogs slaughtered for human consumption may be a previously unrecognized risk factor for potential rabies transmission in the city. The prevalence noted here is in agreement with previous studies from several locations in Nigeria (P. P. [22]; Sabo. G. Umoh, 2008). This result also agrees with the findings of [6] which showed that adult dogs for human consumption were more likely to test positive for rabies antigen compared to puppies. Our results are significant because 50% of positive dogs were sourced from the Plateau State, which is located in close proximity to the study area. The Plateau State is known to be a hub of rabies in Nigeria and its dog market (Dawaki) supplies dogs for human consumption across the country ([3,11]; Sabo, Umoh, Sackey, A, & Okolocha, 2008). The role of slaughtering, handling and consumption of dogs and dog meat in rabies transmission is not well understood. Meat and blood are not sources of rabies virus, but contact with saliva or nervous tissue during slaughtering could pose a risk. Individuals handling and processing slaughtered dogs have been shown to constitute a risk factor for are rabies exposure either from dog bites before slaughter or from infected nervous tissues or saliva which accidentally may contaminate open wounds or bruises during processing of slaughtered dogs [24–26,28]. Risk factors such as not wearing protective coverings, lack of awareness of pre and post exposure prophylaxis of human anti- rabies vaccine, dog bites and exposure of cuts or wounds to brain tissues and saliva during processing of dog meat were observed among dog handlers during the study. Investigation of the role of dog meat consumption on human rabies is required. Movement of dogs for the meat trade also risks transporting rabies virus, if it is endemic in source populations.

In conclusion, this study has demonstrated that paediatric dog bites from local dog breeds during the dog breeding season (with a peak in December–January) is a common epidemiological profile of dog bites in the region. While the level of vaccination coverage in the canine population is inadequate, there may also be a public health risk from dog slaughter facilities which requires further investigation. The evidence from this study can be used to inform integrated and targeted campaigns for local dog breeds in Lokoja in order to reduce the incidence of dog bites, increase dog vaccination coverage and reduce the introduction and spread of rabies to the highly densely populated capital city of the Kogi State of Nigeria.

Author statement.

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript.

The authors declare no conflicts of interest.

References

[1] S.A. Abubakar, A.G. Bakari, Incidence of dog bite injuries and clinical rabies in a tertiary health care institution: a 10-year retrospective study, Ann Afr Med 11 (2) (2012) 108–111, https://doi.org/10.4103/1596-3519.93534.

[2] I. Ahmad, C. Kudi, M. Abbas, Y. Yakubu, U. Muhammad, M. Salisu, Human death from suspected rabid dog bite in Zamfara state, Nigeria, Sokoto Journal of Veterinary Sciences 16 (4) (2018) 92–95.

[3] O. Alabi, P. Nguku, S. Chukwukere, A. Gaddo, P. Nsubuga, J. Umoh, Profile of dog bite victims in Jos plateau state, Nigeria: a review of dog bite records (2006-2008), The Pan African medical journal 18 (Suppl. 1) (2014) 12, https://doi.org/10.11694/pamj.supp.2014.18.1.4341 Suppl 1.

[4] Y. Atuman, Y. Adawa, A. Solomon, P. Mshelbwala, A. Ogunkoya, Potential risks for rabies spill-over from apparently healthy dogs to wildlife in Bauchi state, Nigeria, Journal of Veterinary Advances 4 (4) (2014) 493–498.

[5] S.W. Audu, P.P. Mshelbwala, B.M. Jahun, K. Bouaddi, J.S. Weese, Two fatal cases of rabies in humans who did not receive rabies postexposure prophylaxis in Nigeria, Clin Case Rep 7 (4) (2019) 749–752, https://doi.org/10.1002/ccr3.1972.

[6] S.S. Baba, Detection of rabies virus RNA and antigen in tissues from naturally infected Nigerian dogs; in-situ hybridization and immunohistochemical studies, Revue d' Elevageet de Medicine Veterinaire des pays Tropicaux 52 (2006) 85–91.

[7] CDC, Imported Human Rabies, Retrieved from, 1983. https://www.cdc.gov/mmwr/preview/mmwrhtml/00001248.htm?fbclid=IwAR12pR_9RpuY3iH6jYD3M1UxksvA-mydD7obRyfyppaJKMRjk7HY–hmg5s.

[8] S. Cleaveland, *The epidemiology of rabies and canine distemper in the Serengeti, Tanzania.* (Ph.D), University of London, 1996.

[9] P.G. Coleman, C. Dye, Immunization coverage required to prevent outbreaks of dog rabies, Vaccine 14 (3) (1996) 185–186.

[10] D.J. Dean, M.K. Abelseth, Laboratory techniques in rabies: the fluorescent antibody test, Monogr Ser World Health Organ (23) (1973) 73–84.

[11] A.M.N. Ehimiyein, M.; Orciari, L.; Osinubi, M.O.V.; Ehimiyein, I.O.; Adawa, D.A.Y.; Abdullahi, S.U.; Ogunkoya, A.B. & Rupprecht, C.E, Efficacy of a Direct Rapid Immunohistochemical Test (DRIT) For Rabies Detection in Nigeria. African Journal of Biomedical Research 17 (2014) 101–107.

[12] Eze, U., Anene, B., Chukwu, C., Ogunkoya, A., George, S., Eze, J., … Nwosuh, C. (2015). Risk of typical rabies in dog meat-eating human population, in Enugu, Nigeria.

[13] A.R. Fooks, N. Johnson, S.M. Brookes, G. Parsons, L.M. McElhinney, Risk factors associated with travel to rabies endemic countries, J. Appl. Microbiol. 94 (2003) 31s–36s, https://doi.org/10.1046/j.1365-2672.94.s1.4.x Suppl.

[14] K. Hampson, L. Coudeville, T. Lembo, M. Sambo, A. Kieffer, M. Attlan, J. Dushoff, Estimating the global burden of endemic canine rabies, PLoS Negl. Trop. Dis. 9 (4) (2015) e0003709, , https://doi.org/10.1371/journal.pntd.0003709.

[15] K. Hampson, A. Dobson, M. Kaare, J. Dushoff, M. Magoto, E. Sindoya, S. Cleaveland, Rabies exposures, post-exposure prophylaxis and deaths in a region of endemic canine rabies, PLoS Negl. Trop. Dis. 2 (11) (2008) e339, https://doi.org/10.1371/journal.pntd.0000339.

[16] M. Léchenne, A. Oussiguere, K. Naissengar, R. Mindekem, L. Mosimann, G. Rives, J. Zinsstag, Operational performance and analysis of two rabies vaccination campaigns in N'Djamena, Chad, Vaccine 34 (4) (2016) 571–577, https://doi.org/10.1016/j.vaccine.2015.11.033.

[17] M. Lunney, A. Jones, E. Stiles, D. Waltner-Toews, Assessing human-dog conflicts in Todos Santos, Guatemala: bite incidences and public perception, Prev Vet Med 102 (4) (2011) 315–320, https://doi.org/10.1016/j.prevetmed.2011.07.017.

[18] N.A. Maurice, P.D. Luka, M.N. Maurice, E.O. Ngbede, P.N. Zhakom, P.P. Mshelbwala, L.H. Lombin, Rabies in a set of eight-week old puppies in Nigeria: the need for review of current dog ANTIRABIES vaccination schedule, Afr J Infect Dis 12 (2) (2018) 72–77, https://doi.org/10.21010/ajid.v12i2.12.

[19] C. Mitmoonpitak, V. Tepsumethanon, H. Wilde, Rabies in Thailand, Epidemiol. Infect. 120 (2) (1998) 165–169, https://doi.org/10.1017/s0950268897008601.

[20] P. Mshelbwala, A. Ogunkoya, U. Abdullahi, B. Maikai, Evaluation of two rapid diagnostic tests for rabies diagnosis under field and laboratory conditions in Nigeria, Pan African Medical Journal 5 (2017) 5.

[21] P.P. Mshelbwala, D.K. Akinwolemiwa, B.V. Maikai, R.G. Otolorin, N.A. Maurice, J.S. Weese, Dog ecology and its implications for rabies control in Gwagwalada, Federal Capital Territory, Abuja, Nigeria, Zoonoses Public Health 65 (1) (2018) 168–176, https://doi.org/10.1111/zph.12385.

[22] P.P. Mshelbwala, A.B. Ogunkoya, B.V. Maikai, Detection of rabies antigen in the saliva and brains of apparently healthy dogs slaughtered for human consumption and its public health implications in Abia state, Nigeria, ISRN Vet Sci 2013 (2013) 468043, , https://doi.org/10.1155/2013/468043.

[23] Mshelbwala, P. P., & Weese, J. S. (2017). Rabies in the developing world: challenges & prospects. *Cliniciansbrief. com*.

[24] L.E. Odeh, J.U. Umoh, A.A. Dzikwi, Assessment of risk of possible exposure to rabies among processors and consumers of dog meat in Zaria and Kafanchan, Kaduna state, Nigeria, Glob J Health Sci 6 (1) (2013) 142–153, https://doi.org/10.5539/gjhs.v6n1p142.

[25] P. Owai, A study of rabies in dogs in Calabar, Cross River state, Nigeria, J. Appl. Sci. 12 (3) (2009) 8648–8653.

[26] G. Sabo, J.U. Umoh, A.K.B. Sackey, A. Ahmad, E.C. Okolocha, The role of dog trade in the epidemiology of rabies, Veterinary Clinical Practice Bulletin 1 (1) (2008) 63–72.

[27] Gbeminiyi Richard Otolorin, Jarlath U. Umoh, Asabe Adamu Dzikwi, Prevalence of rabies antigen in brain tissue of dogs slaughtered for human consumption and evaluation of vaccination of dogs against rabies in Aba, Abia State Nigeria, (2014).

[28] W.U.Z. Tariq, M.S. Shafi, S. Jamal, M. Ahmad, Rabies in man handling infected calf, Lancet 337 (8751) (1991) 1224, https://doi.org/10.1016/0140-6736(91)92895-9.

[29] H.F. Wertheim, T.Q. Nguyen, K.A. Nguyen, M.D. de Jong, W.R. Taylor, T.V. Le, H.D. Nguyen, Furious rabies after an atypical exposure, PLoS Med. 6 (3) (2009) e44, , https://doi.org/10.1371/journal.pmed.1000044.

[30] WHO, RabiesWhat Is Rabies? [Press Release], Retrieved from, 2020. https://www.who.int/rabies/about/home_diagnosis/en/.

[31] M.A. Widdowson, G.J. Morales, S. Chaves, J. McGrane, Epidemiology of urban canine rabies, Santa Cruz, Bolivia, 1972-1997, Emerg. Infect. Dis. 8 (5) (2002) 458–461, https://doi.org/10.3201/eid0805.010302.

[32] World Health Organization (WHO): WHO Expert Consultation on Rabies: firs report. WHO Technical Report Serial 931 Geneva, S. (2005). *WHO Expert Consultation on Rabies: firs report. WHO Technical Report Serial 931 Geneva*. Retrieved from.

[33] Akombo PM (2009). Dog Ecology and Epidemiological Studies of Canine Rabies in Benue State, Nigeria. MSc. thesis, Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. Pp 23-42.